

The Economics of Drug Testing

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THE ECONOMICS OF DRUG TESTING

ABSTRACT

What are the economics of establishing a drug free work place? What are the criteria that one needs to consider and what are the parameters that determine cost and effectiveness of drug free workplace programs? Should a company rely solely on urine analysis as the basis of its drug screening policies? What percent of the work force should be randomly tested, if the testing rate not mandated? What are the expected economic benefits from a drug testing program? How can one determine an estimate of the prevalence of drug abuse in one's company from current test results?

These questions and others are addressed in this paper.

The authors review for the reader how much drug abuse by U. S. workers costs businesses. The paper then addresses the various testing opportunities for a company to consider. The expected payoff for various drug policies is addressed. Finally, the authors provide a decision making table for corporations to use as a guide in determining a company testing policy leading to a drug free work place.

BACKGROUND

Decisions on starting, maintaining, or altering drug free work place programs require information that most corporate managers lack. The information is not only lacking, the decision makers, in most cases, fail to realize what information is needed to make drug policy decisions pay off. As reported by the American Management Association, few companies track the benefits of drug free work place programs.

The American Management Association (Machine Office Technology, July 1996, p.23) reported that drug testing in the work place has risen 277 percent since 1987. The AMA reported [1] that eighty-nine percent of responding manufacturing firms do drug testing. Due to Federal regulations, 100 percent of transportation firms test. Seventy-nine percent of wholesalers and retailers, 73 percent of service sector businesses, 60 percent of business service providers, and 56 percent of financial service providers perform drug tests. Only 8 percent, however, have conducted cost benefit analyses.

Two percent of the respondents stated that they terminated drug testing because it was not cost beneficial. The purpose of this paper is to demonstrate that drug testing does indeed have economic value when the prevalence of drug use is two percent or higher. We start by examining the drug testing programs used today.

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Respondents to the American Management Association survey [1] reported 92% use urine sampling, and 79% use no other method of drug testing. Fifteen percent use blood sampling, and 0.8% use only blood samples. Hair sampling is used by 2% of the responding companies, and 0.5% use only hair analysis. Non-medical performance testing is used by 2% of the companies, and 0.2% use only non-medical performance testing.

Urine analysis is the accepted method of drug testing in the work place. More than 90% of these tests are based on urine testing (ODD JOBS, Washington Post, P. H4, Sunday, July 28, 1996). The use of urine analysis dates from 1988 when other technologies were not available. Today, hair analysis is also available. The question is, does hair provide a benefit over urine analysis? This paper evaluates the urine and hair analyses.

According to the American Management Survey, 98 percent of all employees test negative for drugs or two percent test positive. Other surveys report that about ten percent of employees between the ages of 18 to 34, used illicit drugs [2]. In addition, SmithKline Beecham reported that 5 percent of workers tested positive for illegal substances in 1997 [3]. What does this mean? Are there really so few users that are employed, or could it be that the present testing strategies are inadequate?

A look at the reasons that 98 percent of all employees test negative for drugs begins with the validity of the estimate of the number of drug users that are employed. Two-thirds of drug users are employed (Drug Strategies, "Keeping Score," p. 20, 1995). From these statistics one could conclude that random drug screening programs would detect these users at higher percentages than are currently reported. Our analysis shows that the low detection rate is inherent in the most commonly used random sampling process, the prevalence of drug users, the type of drug abused, and the urine screening process.

ANALYTICAL METHODOLOGY

The random sampling process. Let us examine the probability that a drug user will be chosen in a random selection process. We show the effect on the selection probability as functions of work force percentage using illicit drugs (prevalence) and the random selection strategies. The prevalence of drug users and the sampling rate are the major factors in this result. There are two parameters in the random selection process. One is the percentage of people sampled per year and the second is the number of times per year that sampling is performed.

Table 1. shows the selection probability for a work force drug use prevalence of 5%, 10% and 15%. The total percentage of work forces tested yearly was calculated for 25%, 50%, 75%, 100%. For example, the fifty percent random sampling rate in our calculations means that 12.5% of the work force are randomly selected four times a year. The fifty percent sample size is required under Federal regulations. The sampling frequency is left to the employer.

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Probability of a drug using employee being selected in four samples is the product of the probability of an employee being a user times the probability of being selected exactly once in four samples of 12.5% of the work force. (We assume that once employees test positive, they are removed from the sample pool. Employees who test negative may be selected more than once.)

Table 1. Probability of a drug user being selected for random urine testing.

PREVALENCE OF USERS	25% SELECT RATE	50% SELECT RATE	75% SELECT RATE	100% SELECT RATE
5% OF EMPLOYEES	0.0103	0.0167	0.0201	0.0211
10% OF EMPLOYEES	0.0206	0.0315	0.0402	0.0422
15% OF EMPLOYEES	0.0309	0.0502	0.0603	0.0603

Table 1. shows the probability of selecting a drug using employee as a function of sampling rate and prevalence of the drug use in the work force. A drug user who belongs to a low (5%) prevalence use group, can be expected to be urine tested under a fifty percent random sampling process about once in a hundred years. Is it any wonder that only 2% of those tested are found to be using drugs? Note that the probability of being selected increases with an increase in yearly sampling rates. Whether this increase is cost beneficial or not is addressed later.

The drug detection process. The next variable in the drug detection process is the likelihood that a selected drug user will have drug metabolites in his or her urine at detectable levels. Employees who use drugs at least once per day will always have detectable levels of drug metabolites in their urine. The detection of occasional users is a function of the drug used, the frequency of use, the magnitude of drug use, and the person's metabolic rate.

Except for marijuana and PCP, most drugs metabolize rather quickly. The table demonstrates why drug tests should be administered with a minimum of warning time. For pre-employment testing, advanced notice is difficult to avoid. Periodic random testing can be administered with little warning.

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Table 2. Likely period after use for detection of illicit drugs in urine.

ILLCIT SUBSTANCE	DETECTION LEVEL	PERIOD OF LIKELY DETECTION
HEROIN	300 NG/ML	1-4 Days [7]
COCAINE	300 NG/ML	8-48 Hours [7]
MARIJUANA	100 NG/ML	7-34 Days [7]
LYSERGIC ACID DIETHYLAMINE (LSD)	20 NG/ML	2 Days [6]
PHENCYCLIDINE (PCP)	75 NG/ML	5-10 Days [7]

Detection probability determination process. The prevalence of occasional drug users and those who could be classified as addicts and the drug of choice brings other variables into the detection probability equation. In this analysis, we assumed that 50 percent of the drug users use drugs at such a rate that their urine is always positive. For the other 50% we used a mathematical model described in the next paragraph. For the analysis, the authors chose only marijuana and cocaine as likely drugs of abuse. Marijuana is the most used illicit drug of the two, so we assumed that 70% of the drug users would be marijuana smokers and 30% would be cocaine users. The occasional marijuana or cocaine user in this study is one who uses the drug once every seven days.

Detection Probability Model for Casual Users.

In our model, we assume that a casual user has a probability (a) of using a drug per day. We assume that this probability (a) is constant and independent of time. These assumptions define the applicability of the Poisson statistical probability distribution:

$$P_n(t) = [(at)^n / n!] e^{-at}$$

Where $P_n(t)$ is the probability that a person has used the drug exactly n times from time zero to time t, where n! is the mathematical expression for n factorial, and e is the base for natural logarithms. In particular, $P_0(t)$ is the probability that a person has not used the drug from time zero to time t. And $1 - P_0(t)$ is the probability that a person has used a drug at least once in the last t days.

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For occasional marijuana users: Using an average time between usage as seven days, probability of use per day is 0.14. Using the seven day detection window from Table 2., the probability that a person used marijuana and whose urine exceeds urine test thresholds in the last seven days is 0.62.

For occasional cocaine users: Using an average time between occasional cocaine use as seven days, probability of use per day is 0.14. Using the two day detection window from Table 2., the probability that a person used cocaine and whose urine is at a level exceeding urine thresholds within the last two days is 0.44.

RESULTS OF ANALYSIS

The results are summarized in Tables 3, 4, and 5. Table 3. shows the probability of a marijuana user being selected and failing a urine test as a function of prevalence and sampling strategies. Table 4. shows the probability of a cocaine user being detected as a function of prevalence and selection strategies. Table 5. is the probability that either one would be detected, again as a function of prevalence and sampling rate.

Table 3. Probability of a marijuana user being selected and failing a urine test.

PREVALENCE OF MARIJUANA USERS	25% SELECT RATE	50% SELECT RATE	75% SELECT RATE	100% SELECT RATE
3.5%	0.0058	0.0095	0.0114	0.0120
7 %	0.0117	0.0190	0.0228	0.0239
10.5%	0.0175	0.0285	0.0342	0.0359

Table 4. Probability of a cocaine user being selected and failing a urine test.

PREVALENCE OF COCAINE USERS	25% SELECT RATE	50% SELECT RATE	75% SELECT RATE	100% SELECT RATE
1.5%	0.0018	0.0029	0.0035	0.0046
3%	0.0036	0.0058	0.0087	0.0091
4.5%	0.0067	0.0108	0.0130	0.0137

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Table 5. Probability that either a marijuana or cocaine user will be detected.

PREVALENCE OF ALL USERS (MJ OR COCAINE)	25% SELECT RATE	50% SELECT RATE	75% SELECT RATE	100% SELECT RATE
5%	0.0076	0.0124	0.0149	0.0165
10%	0.0036	0.0248	0.0315	0.0330
15%	0.0242	0.0393	0.0427	0.0495

Table 5. is the sum of Tables 3. and 4. The tables were generated independently and the values may differ from the expected sums due to rounding. Table 5. shows that if ten percent of a work force uses marijuana or cocaine, then the company that randomly tests 50% of this work force, and samples these four time a year, will expect to catch about three people for every one hundred sampled, or a three percent positive rate. If it costs a company \$100 to test each employee, then the cost to test 100 people is \$10,000. This raises the question is it worth \$10,000 to a company to catch three drug abusing employees? Is there economic benefit in random urine testing? This is the question raised by the American Management Association.

A drug user costs a company about \$7500 per year [4]. These costs are due to loss in productivity, accidents, tardiness, absenteeism, theft, worker compensation claims, etc. Thus a prevalence of ten percent of drug users in a work force will cost a company \$75,000 per year per hundred employees. The expected value of the random drug testing program is the product of the expected number of people caught times the total cost of having drug abusing employees. In this illustration the expected number of people caught is 2.48 per 100 tested with an expected savings of \$18,600 for an investment of \$10,000 per one hundred employees. The pay off is \$1.86 for every dollar invested. The cost for having a drug abusing employee must be below \$4,032 per year before drug testing is financially a poor policy with this strategy.

How do other random testing strategies affect this payoff? How does sampling higher or lower percentages affect this pay off? How does the frequency of performing the tests affect this payoff? These questions are addressed below.

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SAMPLING RATE EFFECTS ON EXPECTED PAYOFF

Table 6. shows the expected pay off for sampling at four different rates, four times a year:

6.5 employees per hundred (25%),
12.5 employees per hundred (50%),
18.7 employees per hundred (75%), and,
25.0 employees per hundred (100%).

Prevalence rates of five, ten, and fifteen percent were used. An estimated cost of \$100 per sample was used based on laboratory cost, program costs, and lost of productivity costs. Table 6. shows the expected payoffs for four sampling rates and the three prevalence rates. The payoff is the difference between the expected savings per test and the estimated cost per test.

Table 6:

The expected payoff of drug testing as function of percent sampled four times per year.

PREVALENCE OF USERS	25% SELECT RATE	50% SELECT RATE	75% SELECT RATE	100% SELECT RATE
5% USE MJ OR COCAINE	-\$42.78	-\$6.95	\$11.75	\$23.87
10% USE MJ OR COCAINE	\$14.44	\$86.09	\$136.24	\$147.75
15% USE MJ OR COCAINE	\$81.45	\$195.06	\$254.36	\$271.62

Two conclusions were made from this payoff chart. One, with low prevalence rates, random sampling of 50% or less is financially a bad policy. Two, sampling a large percentage of the work force pays higher returns. For example, sampling seventy-five percent of a 5% prevalent work force would return about \$12, while the 25% and 50% sampling rates have negative returns. The conclusion then is to sample at high percentage rates. In fact, a sampling strategy of 100% has the best pay off down to prevalence rates less than two percent. Below two percent no strategy has an expected positive payoff.

A company with an estimated drug prevalence rate of less than 2% would test for reasons other than a cost savings. Regardless, 100% testing would result in the highest payoff policy.

SAMPLING FREQUENCY EFFECTS ON EXPECTED PAYOFF

How often should one conduct random sampling? One, two, three, four or more times per year? Based on this statistical analysis, the authors conclude that it is best to test once per year and to

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test everybody. This strategy ignores the deterrence affects of multiple sampling. The perception is that if multiple samples of the work force is taken periodically, than a user is more likely to be selected and detected as a user. Actually the chance of being selected and detected is much higher if 100% testing is performed. This is due to the affect of sampling the work force with replacement. This is a mathematical way of saying that an employee is put back into the selection pool and may be tested more than once per year and some employees may not be selected at all, even with 100% (25% four times a year) selection rates. The chance that an individual is selected at least once under these conditions is 0.68 which means that a user has a 32% chance of not being picked to be tested!

The most efficient random program is based on the randomness of choosing the one day to sample everybody and not on how many and when to sample smaller groups. Figure 1. shows the effects of sampling frequency. The Y-axis is the probability of detecting users and the X-axis is the number of times per year the sampling is conducted. Figure 1. is based on a prevalence of five percent and a sampling strategy of 50% of work force per year with replacement.

This recommendation does not take into account the affect of that multiple sampling has as a deferent to the work force. One could assume that if the employees know that they will be tested only once a year, then they will tend to abuse drugs more after the yearly test is conducted. The counter to that is that it is most likely that addicts or users that require at least one dose per day will continue to use drugs regardless of the corporate policy. The hard core addict or user is the user who most likely will cost a company money.

The recreational user will continue to use drugs occasionally and will be very difficult to detect. These occasional users, if impaired at work, are best detected by the observations of their supervisors and reports by fellow employees. Once a year testing will catch the addicts or the more than one dose a day user and some of the occasional users. The recommended sampling selection policy incorporates stratification of the employee population by risk of being a user. This is explained in the next section.

EMPLOYEE SAMPLING STRATIFICATION

Stratification process. Establishing employee sampling strata and sampling each population based on degree of risk was analyzed by the authors. We found that stratification is easily achievable and cost effective. Three employee sampling categories were developed based on urine and hair testing analyses results.

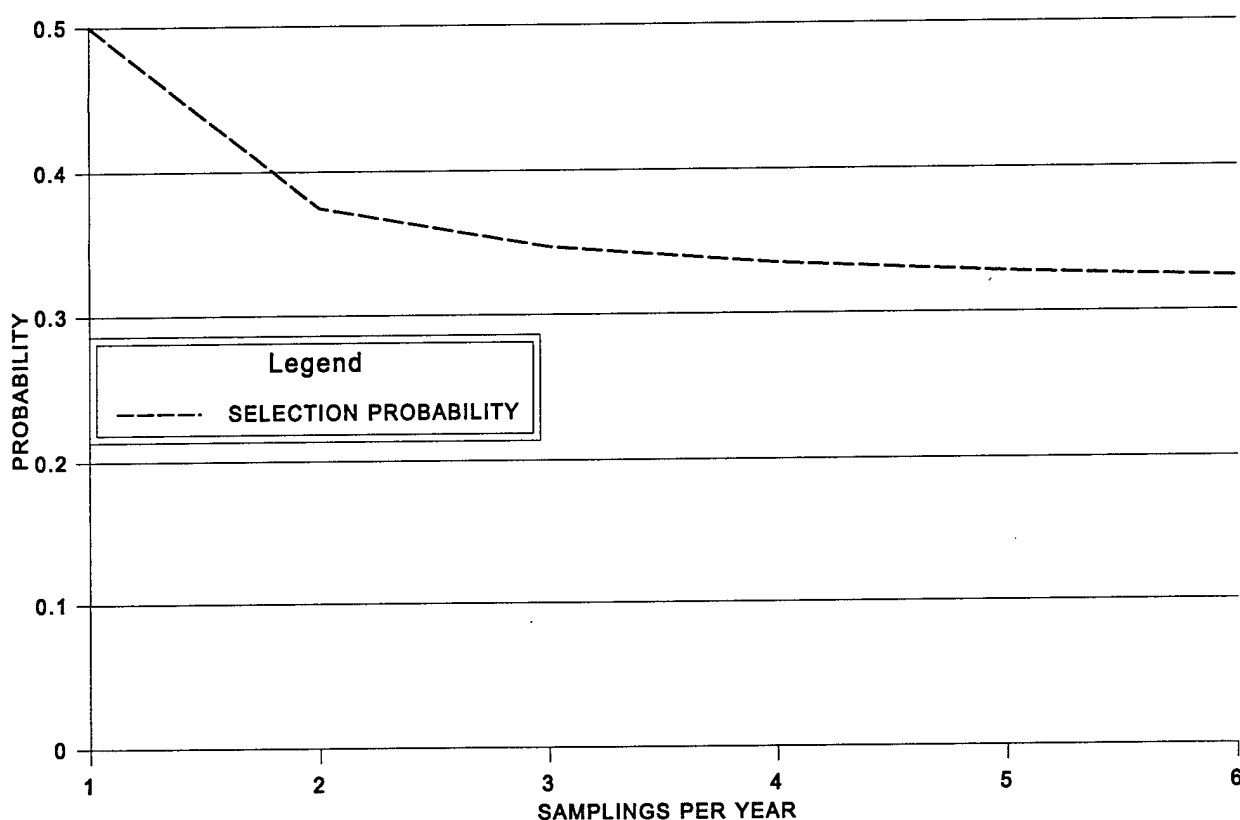
The established Federal (SAMHSA) urine cutoff levels (thresholds) were developed by manufacturers to produce optimum performance of urine test kits [8] thresholds independent of impairment levels. Hence, for drug testing a non-mandated company can ignore thresholds and should request its drug testing laboratory to test urine down to the lowest detection level of their

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GC/MS (gas chromatograph/mass spectrometer).

SAMPLING FREQUENCY EFFECTS

FIGURE 1



The results from these tests can allow one to arrange employees into different groups whose sampling rate differs by the degree of risk an employee represents to the company. For example, if an employee is tested two times and no illicit drug metabolite is presence in the specimen, than this employee could be sampled less frequently, say 25% rather than 50% random pool as required by the Department of Transportation [9]. An employee who had at least one urine sample show presence of illicit drug metabolite, but below the Federal guidelines, could be put into a pool of tested at 100% until a string of negatives test results are achieved. Employees

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whose urine contains metabolites exceeding the Federal cutoff levels will need to be put into a third group and tested more frequently and 100%.

The use of hair as a specimen adds even more criteria [10] for drug testing stratifications in a work force. Hair provides an observation period of about 60 to 90 days [5]. The use of hair analysis results greatly increases the likelihood that a person whose hair and urine contain no drug metabolites is not an user.

This employee is placed in a low prevalence group with a low percentage of sampling. The low sampling policy is more of a deterrent to thwart future use, rather than one based on cost benefit. The payoff value of using both urine and hair is shown in Table 7.

Table 7. Payoffs using hair and urine testing.

PREVALENCE OF USERS	25% SELECT RATE	50% SELECT RATE	75% SELECT RATE	100% SELECT RATE
5% USE MJ OR COCAINE	-\$23.52	\$24.35	\$49.35	\$56.62
10% USE MJ OR COCAINE	\$52.95	\$148.71	\$198.69	\$213.24
15% USE MJ OR COCAINE	\$129.42	\$273.06	\$348.04	\$369.86

Comparing Table 6. (Payoff with urine only) and Table 7. (payoff with urine and hair) shows the expected added return of using both specimens. The payoff for using both hair and urine is approximately double that of a program based solely on urine analysis.

The authors have developed an employee stratification program which is a far more effective selection, detection, and ultimately deterrent than the present day concept of random testing based solely on urine specimens. We place employees into one of three risk categories. (Risk meaning the likelihood that they are drug users.)

The three categories of employees are:

- Very low risk employees (prevalence rate close to zero),
- Moderate risk employees (prevalence rates close to 100%), and
- High risk employees (prevalence rate at 100%).

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The groups are defined by:

- Test all employees at least twice in one year
- Collect and analyze urine and hair specimens
- Analyze all specimens at established threshold standards
- Analyze all negative specimens to lower detection limit of GC/MS
- Category 1 employees: Employees whose urine and hair analyses contain no illicit drug metabolite after two tests.
- Category 2 employees: Employees whose urine or hair contains illicit drug metabolite at levels below thresholds.
- Category 3 employees: Employees whose urine or hair contains illicit drugs above the threshold levels.

Employees in the low risk group will be selected for drug (urine and hair) testing at a 25% rate, four times per year (6.25% each selection). This is for deterrence only. The cost for this program will exceed the expected value.

The employees in the moderate risk group will be tested (urine and hair) four times a year, with 100% sampling each selection. The employees in the high risk group will be tested weekly.

Testing the total work force of a hundred employees twice in six months would cost \$20,000. The expected payoff for identifying the ten illicit drug users from this strategy would be \$75,000. Assuming that the prevalence rate is 10%, then the expected number of employees who would screen negative with urine and hair would be 90. These employees will be tested at a 25% rate the following year at a cost of \$2250. Assume that of the ten employees tested, those who were above the lower detection limit and below the urine or hair thresholds number five. These five people would be tested four times a year, 100% each sample at a cost of \$2000. The remaining five people, who tested above the urine or hair thresholds, would be tested weekly with urine specimens. Again the lower detection limit of the GC/MS would be used, i.e. no cut off thresholds. This would continue until either the employee's urine were completely clean or until the employee was removed from the work force.

For water soluble drugs such as cocaine, we estimate that zero levels of metabolite should be expected after two weeks. The metabolite for marijuana would take about six weeks to disappear from the urine. The levels of metabolites should be decreasing or at most staying level on weekly test results. The expected cost of this program is \$3000. Once an employee tests negative down to the lower detection limit of the GC/MS, these five employees would be retained in the high risk category and be subject to testing four times a year at a cost of \$2000. Employees, in the moderate risk level strata can be placed in the low risk population only after two years of negative metabolite readings in either urine or hair. Employees who are placed into the high risk group from the moderate risk group will be tested weekly for six weeks.

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The first year cost of the program is \$27,250 with an expected payoff of \$47,750. Assuming, the prevalence rate drops to five percent with this program, the second year cost are \$2375 for the low risk group, about \$1200 for the moderate risk group, and \$1800 for the high risk group. This totals \$5375. Thus the expected pay off would be $(\$37,500 - \$5,375)$ \$32,125.

This compares favorably to the cost benefit of 50 percent random testing without stratification. Using Table 6., which says the expected payoff would be \$8,609 per year or \$17,218. The employee sample stratification is practical and cost effective.

Reasonable suspicion and post accident testing is still recommended for all employ sampling groups. Reasonable suspicion testing is testing that is conducted on a specific employee because a trained observer (supervisor) has detected behavior, odors, or impairment. The supervisor needs to be trained in detect signs of both drugs and alcohol abuse. This training, and the policy of reasonable suspicion testing, is recommended.

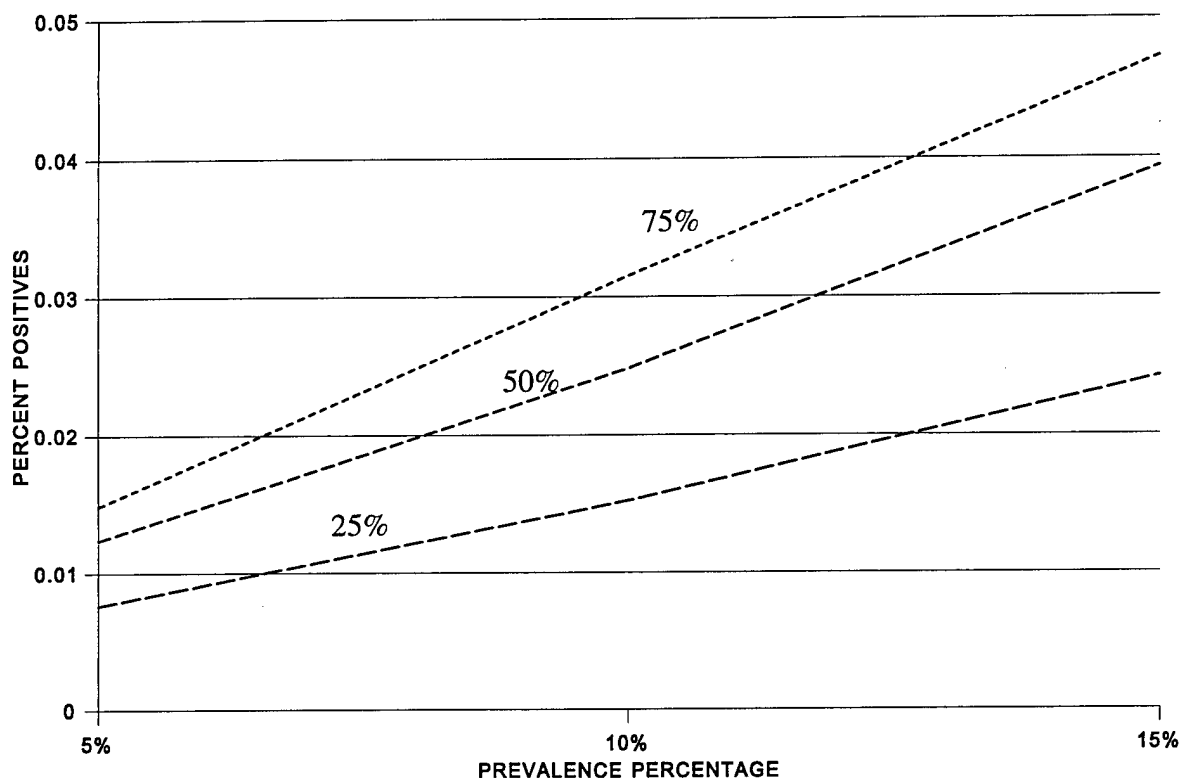
ESTIMATING PREVALENCE FROM HISTORICAL TEST RESULTS

How is a company to know its prevalence rate for drug abuse? Once you test, or if you tested in the recent past at either a 25%, 50%, or 75% rate, Figure 2. can be used to provide you with an estimate of prevalence in a company. Returning to the American Management Association study that reported a 2% positive rate, one could use Figure 2. and estimate that population of users in this survey.

The Y-axis of the chart is the detection rate experienced. For a 75% selection rate the prevalence of users is estimated at 6.25%. For 50% and 25% selection rates the prevalence is estimated at eight and 12.5% respectively. This chart was based on a number of assumptions and these limit any precision in the estimate. However, the model will provide a decision maker with an estimate that could be used in establishing drug policy changes.

PREVALENCE PREDICTOR

FIGURE 2



CONCLUSIONS

Drug testing programs used today can be greatly improved. Both urine and hair should be used with detection of metabolites reported above the lower detection limits of the GC/MS for all sample specimens. Stratification of employees into statistical risk groups is easily accomplishable and has extremely large payoffs. Prevalence in a work force can be estimated by using historical testing results data and a simple graph developed by the authors.

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RECOMMENDATIONS

Refinements to the prevalence predictor model should be made by including more than the two drugs chosen by the authors. Data on heroin, methamphetamine, and PCP abuse should be included to ensure a more accurate prevalence estimate. More accurate and extensive data on metabolite concentrations as a function of time after use is needed to improve the detection probabilities estimates. Cost benefits of using employee sampling stratification needs to perform on a test population of employees along with a control group.

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